The Lakes of Maple Valley and Covington

A Report on Monitoring Results for the 2012 Water Year at Lake Lucerne, Pipe Lake, and Lake Wilderness

Lake Wilderness, July 2011 *photo by Sally Abella, Lake Stewardship Program*

Prepared for the Cities of Maple Valley and Covington

by the King County Lakes and Streams Monitoring Group

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Overview

The King County Lakes and Streams Monitoring Group and its predecessor the Lake Stewardship Program have worked with volunteers to monitor water quality for three lakes that are currently completely or partially within the Cities of Maple Valley and Covington. Lake Lucerne data has been collected since the 1980s, while Pipe and Wilderness Lakes have been monitored since the 1970s. The water quality data indicate that the three lakes currently range from low to moderate in primary productivity, with generally good water quality.

This report refers to two common measures used to predict water quality in lakes: the Trophic State Index or TSI (Carlson 1977), and the nitrogen to phosphorus ratio (N:P). The TSI and N:P ratios were calculated from the data collected through the King County Lake Stewardship (KCLSP) volunteer monitoring program.

TSI values are derived from a regression that relates values of a parameter such as total phosphorus, chlorophyll *a* or Secchi transparency to a predicted algal biovolume, assigning a number on a scale of 0 to 100. This scale can be used to compare water quality over time and between lakes. The TSI values at each of the lakes in Maple Valley have been relatively stable for at least the last 13 years, with no statistically robust trends of declining water quality evident for any of the lakes.

The discussion in this report focuses on the 2012 water year. Specific data used to generate most of the charts in this report can be downloaded from the King County Lake Stewardship data website at:

http://your.kingcounty.gov/dnrp/wlr/water-resources/small-lakes/data/default.aspx

Data can also be provided in the form of excel files upon request.

Lake Lucerne

While a small number of samples were taken in the 1970s, consistent volunteer monitoring began at Lake Lucerne in the 1980s and continued through 2012, with only one gap in the early 1990s. The data indicate that this 16-acre lake is relatively low in primary productivity (oligotrophic - mesotrophic) with good to excellent water quality.

Lake Lucerne has no public access boat launch, but does have a history of both milfoil and hydrilla infestations for which eradication efforts have been underway since 1995. Milfoil has been eradicated, and the last hydrilla plant was found six years ago. Lake Lucerne has not been treated with the herbicide fluridone (Sonar PR ™) since 2008 and had no residual levels of the herbicide when last tested in spring 2010. The year 2012 was the third year that adjoining Pipe Lake was no longer treated. King County and its contractor will continue to monitor as aquatic plants begin to recolonize the shallow water zones of the lake. Lake users and residents should keep a close eye on aquatic plants growing nearshore to catch new or expanding patches of noxious weeds.

Physical Parameters

No precipitation or lake level data were collected for Lake Lucerne in 2012.

Secchi transparency is a common method used to assess and compare water clarity. It is a measure of the water depth at which a black and white disk disappears from view when lowered from the water surface.

Volunteers collected Secchi depth transparency and 1m temperature data from early May through late October during the "Level 2" monitoring season when volunteers collect water samples for laboratory analysis. Secchi transparency ranged between 3.5 and 6.5 meters (m) from May through October (Figure 1), averaging 4.9 m, which is fairly typical clarity for Lake Lucerne. The lower values in late spring are indicative of spring algae growth before zooplankton become more active and grazing decreases algal abundances.

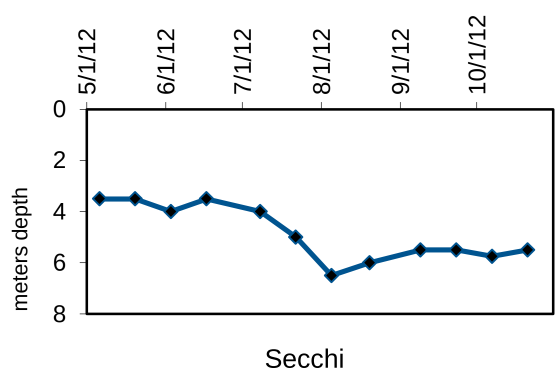

Figure 1. WY 2012 Lake Lucerne Secchi Depth

Surface water temperatures reached ranged from 14.5 to 25.0 degrees Celsius, with an average of 20.5 degrees (Figure 2), which was the warmest of the monitored lakes in 2012 and was also slightly warmer than in 2011. A large jump in temperature during May was followed by little change until July, likely due to the wet and cool period in June and early July that the Puget Sound region experienced.

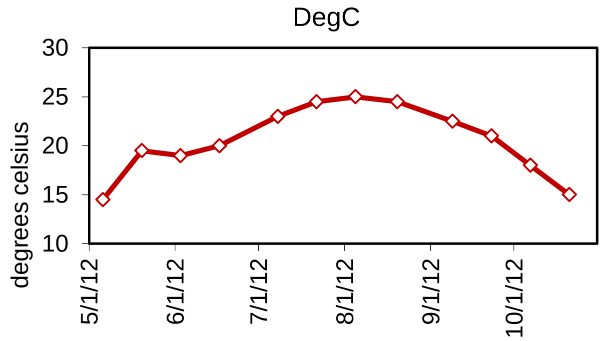

Figure 2. WY 2012 Lake Lucerne Temperature

Mean summer water temperatures over the years that Lake Lucerne has been monitored have varied (Figure 3), but to-date show no statistically strong trend toward change through time. Although a trend line run through the data is slightly decreasing over time, the correlation coefficient of the line is low and does not support a trend.

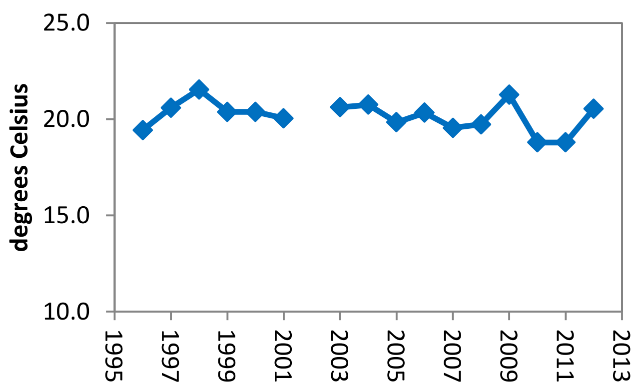

Figure 3. Mean May – October 1m water temperatures for Lake Lucerne

Nutrient and Chlorophyll Analysis (Lake Lucerne)

Phosphorus and nitrogen are naturally occurring elements necessary in small amounts for both plants and animals. However, many actions associated with residential development can increase concentrations of these nutrients beyond natural levels. In lakes of the Puget Sound lowlands, phosphorus is often the nutrient in least supply, meaning that biological productivity is often limited by the amount of available phosphorus. Increases in phosphorus concentrations can lead to more frequent and dense algae blooms – a nuisance to residents and lake users, and a potential safety threat if blooms become dominated by cyanobacteria (bluegreen algae) that can produce toxins. Samples collected by volunteers are analyzed for total phosphorus (TP) and total nitrogen (TN) concentrations at one meter depth.

TN concentrations began slightly higher in spring and tapered off until in late summer, remaining stable for the rest of the monitoring season. Phosphorus was generally stable at low levels throughout the season (Figure 4).

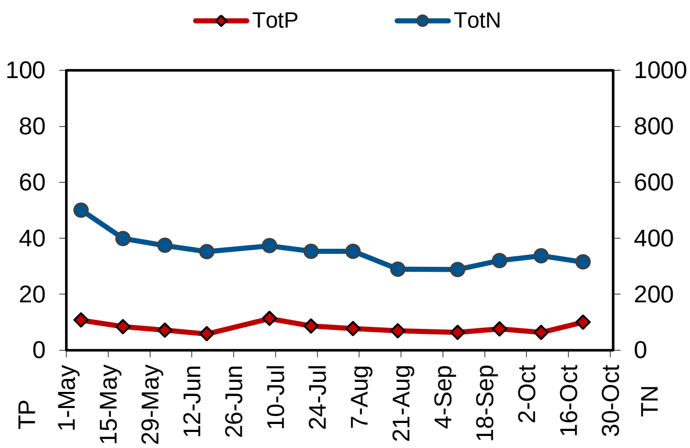

Figure 4. WY 2012 Lake Lucerne Total Phosphorus and Total Nitrogen Concentrations

The ratio of nitrogen (N) to phosphorus (P) can be used to determine if nutrient conditions are favorable for the growth of cyanobacteria that can impact beneficial uses of the lake. When N:P ratios are near 25 or below, cyanobacteria may have a competitive advantage in the algal community due to their ability to take nitrogen from the air.

Total phosphorus and total nitrogen remained in relatively constant proportion to each other through the sampling period, ranging from 29.7 to 71.4 with an average of 47.7, which suggests generally poor conditions for the growth of nuisance bluegreen algae at Lake Lucerne (Figure 5).

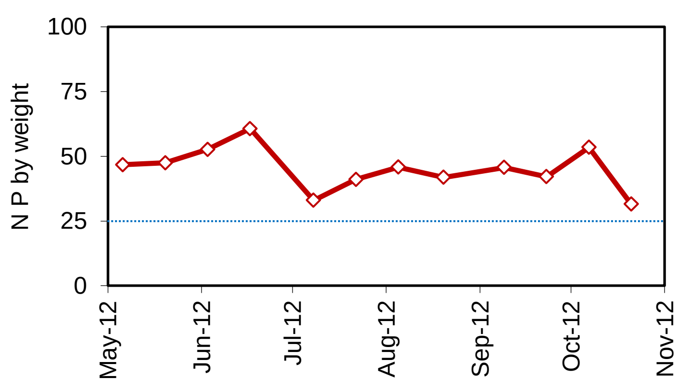

Figure 5. 2012 Lake Lucerne N:P ratio. Values below the blue line indicate a potential nutrient advantage for cyanobacteria.

Chlorophyll *a* concentrations remained relatively low throughout the season, with the maximum on the first sample date in spring, a small increase in July, and a slight rise at the end of October. These seasonal changes represent a peak in phytoplankton activity in spring when light levels increase and nutrients are abundant and a growth increase in late fall when the water in the lake mixed thermally, bringing nutrients up from the hypolimnion. Pheophytin, which is degraded chlorophyll, was at levels near or below detection levels throughout the period (Figure 6). A similar pattern was found in adjacent Pipe Lake.

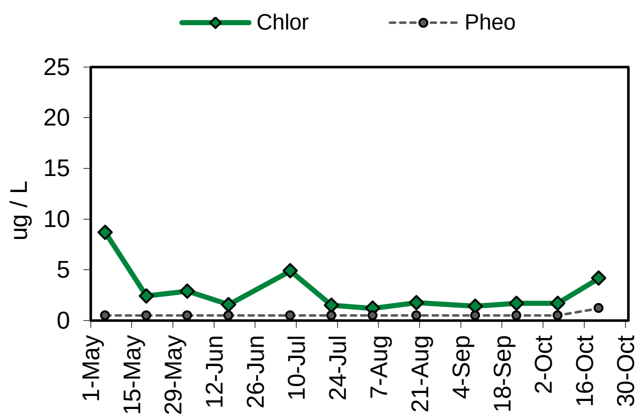

Figure 6. 2012 Lake Lucerne Chlorophyll *a* and Pheophytin concentrations

Water column profiles

Profile temperature profile data indicate that thermal stratification was present by mid-May and persisted through the summer (Table 1).

Table 1. 2012 Lake Lucerne profile sample results. Secchi and Depth in meters. Temperature in degrees Celsius. Chlorophyll and Pheophytin in ug/L. Nitrogen, phosphorus, and alkalinity in mg /L. UV254 in absorption units. Sample values below minimum detection level (MDL) are marked in bold, red with the MDL value.

Lake name	Date	Secchi	Depth	DegC	Chlor-a	Pheo	Total N	NH3	Total P	OPO4	UV254	Total Alk
Lucerne	5/20/12	3.5	1	19.5	2.42	**0.5**	0.399	0.021	0.0084	0.0032	0.0849	31.7
Lucerne			5	12.0	12.00	**0.5**	0.485		0.0106			
Lucerne			9	8.0			0.596	0.171	0.0119	0.0072		
Lucerne	8/20/12	6.0	1	24.5	1.75	**0.5**	0.289	0.009	0.0069	**0.002**	0.055	34.0
Lucerne			5	20.0	3.47	**0.5**	0.268		0.0068			
Lucerne			9	10.0			0.786	0.190	0.0478	**0.002**		

Concentrations of total phosphorus (Total P) in the deep water remained relatively low, though the deep water concentration did increase by the end of August. The amount of orthophosphate (OPO4) also was low on both dates, indicating there was no major release of phosphorus from the sediments. In addition small amounts of ammonia were found in the deep water on both dates, suggesting the deep water was lower in oxygen content than the 1m water. However, the low phosphorus values in the deep water indicate internal loading of phosphorus to the lake was relatively low.

Chlorophyll *a* data (Chlor-a) indicate that algae were more abundant in the middle of the water column in May, but distributed more equally through the upper depths of the water column at lower concentrations in August, with little degraded chlorophyll present (pheophytin). The Secchi transparency is consistent with this, being less clear in May than in August.

Alkalinity, also known as acid neutralizing capacity or buffering capacity, was relatively low, meaning the lake is somewhat sensitive to acidification. The water color (UV254) was very low, indicating that dissolved organic carbon was not abundant in the lake water.

TSI Ratings (Lake Lucerne)

A common method of tracking water quality trends in lakes is by calculating the "trophic state index" (TSI), developed by Robert Carlson in 1977. TSI indicators predict the biological productivity of the lake based on water clarity (Secchi) and concentrations of TP and chlorophyll *a* (see discussion in the overview).

The 2012 TSI values for chlorophyll and Secchi were in the low-mid range of mesotrophy and TSI-TP was significantly lower (Figure 7). The average of the three values was 37.9; putting Lake Lucerne in the upper range of oligotrophy, indicating it is fairly low in primary productivity. The relationships between the 3 different indicators have held relatively steady for the past 4 years, with the phosphorus concentrations predicting low algae populations. Over that last two years, the chlorophyll and transparency indicators have been very close together.

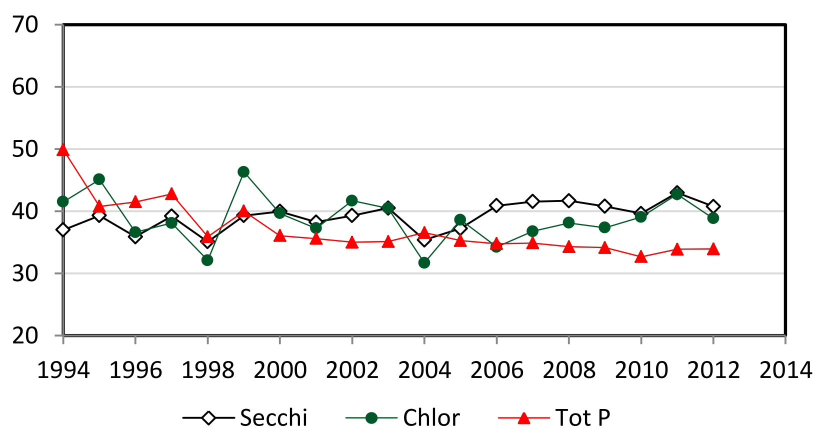

Figure 7. Lake Lucerne Trophic State Indicators

A trend line run through the TSI-TP indicator values since 1998 shows a significant decreasing trend over time (Figure 8). The correlation coefficient of 0.562 indicates that 56% of the variability can be explained by a downward trend. This suggests that the large stormwater pond in the Brown Plat development has been sufficient to-date in preventing an increase in nutrients from entering Lake Lucerne from the building and occupation of new residences in the watershed.

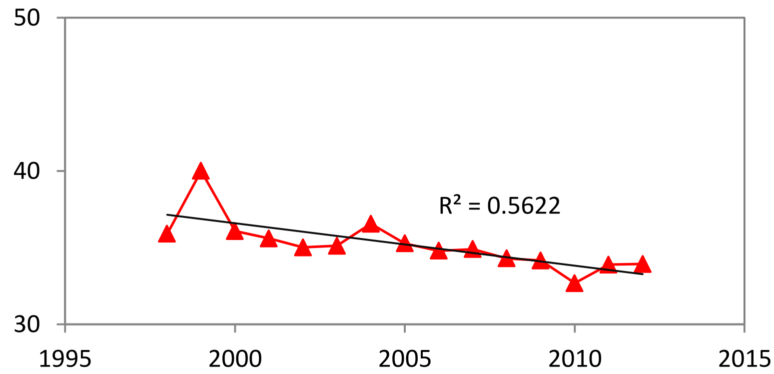

Figure 8. Lake Lucerne TSI-TP trend since 1998

Conclusions and Recommendations

Based on monitoring data, overall water quality in Lake Lucerne appears to have been stable over the period measured. High N:P ratios indicate conditions are not favorable for nuisance bluegreen algae blooms.

Residential development continues in the Lake Lucerne watershed, and the lake should continue to be monitored to insure that stormwater inputs from increased development do not affect the water quality of the lake.

With the sunset of herbicide treatments as part of the hydrilla eradication project in both Pipe and Lucerne Lakes, the city and the residents around the lake should be vigilant in looking for invasive aquatic plants colonizing the lake, such as Eurasian watermilfoil, in addition to the return of native aquatic plants.

Pipe Lake

Volunteer monitoring began at Pipe Lake in the 1970s and has been continuous since the early 1990s. The data indicate this 52-acre lake is fairly low in primary productivity (high oligotrophic) with very good water quality. Nearly 55% of the shoreline of Pipe Lake is in the City of Maple Valley. The remainder is in the City of Covington.

Pipe Lake has no public access boat launch, but there is a community boat launch at Cherokee Bay. The lake is connected to Lake Lucerne by a short, shallow channel and has a history of both milfoil and hydrilla infestations for which eradication efforts have been funded by government agencies since 1995. Eurasian watermilfoil has been eradicated, and the last plant of hydrilla was found in 2006. The year 2012 is the third one in which no herbicide was applied to the lake. Instead, a diving survey focused on finding any remaining hydrilla and documenting the return of native aquatic plants to the lake. Residents should watch aquatic plants growing nearshore to catch growing patches of milfoil, Hydrilla or other noxious weeds. To date no hydrilla has been found and no other submerged noxious aquatic weeds have been identified.

Physical Parameters

No precipitation or lake level data were collected for Pipe Lake in 2012.

Volunteers collected Secchi transparency and temperature data from early May through late October during the “Level 2” monitoring season when volunteers collect water samples for laboratory analysis. Secchi transparency from late May through October ranged from 3.3 to 5.1 m, averaging 4.4 m, which placed it among the clearest lakes during the 2012 monitoring (Figure 1). This was not quite as clear as in 2011 when the average was 5.0 m

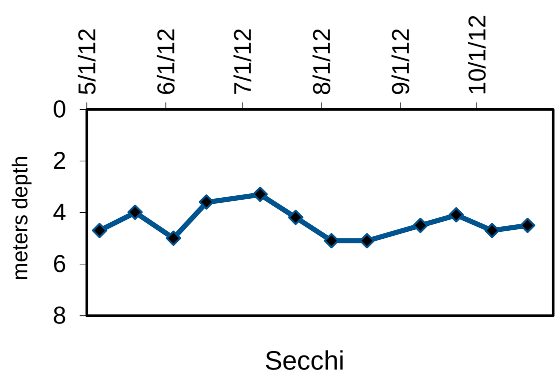

Figure 1. WY 2012 Pipe Lake Secchi Depth

Water temperatures for the same period ranged from 15.0 degrees Celsius to a peak of 26.0 degrees Celsius with an average of 19.5, which was among the warmer lakes in 2012, but cooler than the previous year (Figure 2). The dip in temperature recorded in late July was not seen in the temperature curves of other monitored lakes in the region and may represent a thermometer malfunction or reading error.

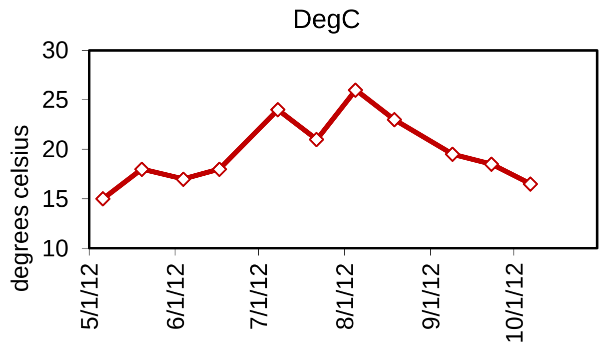

Figure 2. WY 2012 Pipe Lake Temperature at 1m

Mean summer water temperatures over the years that Pipe Lake has been monitored have varied between years (Figure 3), but to-date show no statistically strong trend toward change through time. A trend line run through the data is flat with a very low correlation coefficient, suggesting stability through the years monitored with no directional trend.

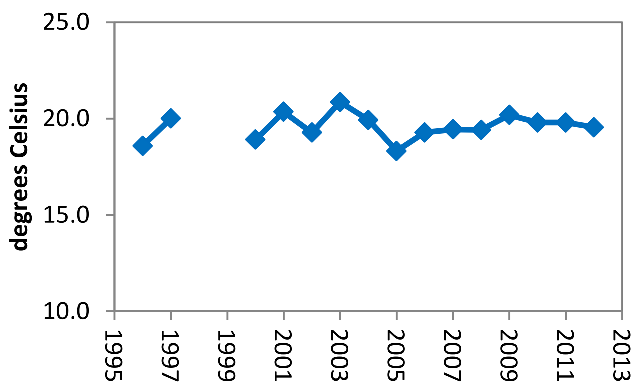

Figure 3. Mean May – October 1m water temperatures for Pipe Lake over time

Nutrient and Chlorophyll Analysis (Pipe Lake)

Phosphorus and nitrogen are naturally occurring elements necessary in small amounts for both plants and animals. However, many actions associated with residential development can increase concentrations of these nutrients beyond natural levels. In lakes of the Puget Sound lowlands, phosphorus is often the nutrient in least supply, meaning that biological productivity is often limited by the amount of available phosphorus. Increases in phosphorus concentrations can lead to more frequent and dense algae blooms – a nuisance to residents and lake users, and a potential safety threat if blooms become dominated by species that can produce toxins. Samples collected by volunteers are analyzed for total phosphorus (TP) and total nitrogen (TN) concentrations at one meter depth.

Total nitrogen declined from early May through late August and remained stable from then until the end of the monitoring season in late October (Figure 4). Total phosphorus remained low through the entire season, with small variations between dates. Note that the TN scale is 10x the value of the TP scale.

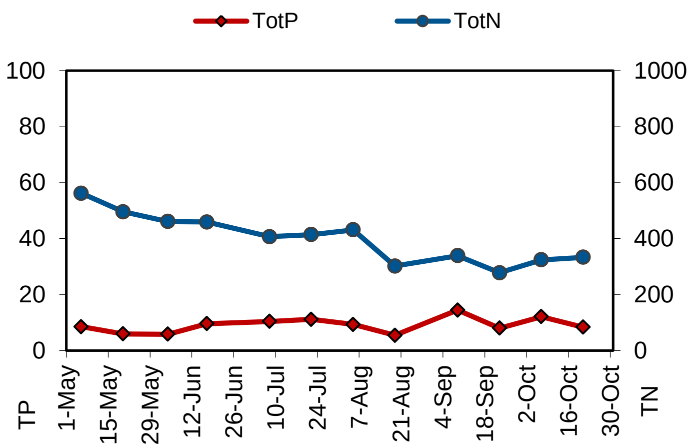

Figure 4. 2012 Pipe Lake Total Phosphorus and Total Nitrogen. Concentrations in ug/L.

The ratio of nitrogen (N) to phosphorus (P) can be used to determine if nutrient conditions are favorable for the growth of cyanobacteria that can impact beneficial uses of the lake. When N:P ratios are near 25 or below, cyanobacteria may have a competitive advantage in the algal community due to their ability to take nitrogen from the air.

The N:P ratio ranged from 23.5 to 84.1, averaging 48.4, which is slightly smaller than in previous years, but still indicates generally poor nutritional conditions for nuisance cyanobacterial growth (Figure 5). Note that the ratio decreased through the season and was at its lowest in fall. This is the time of the year when many lakes in the Puget lowlands support large amounts of cyanobacteria and, if this pattern continues in the future, might indicate that Pipe Lake could host them as well, although the overall low values of phosphorus would be likely to keep the abundances down.

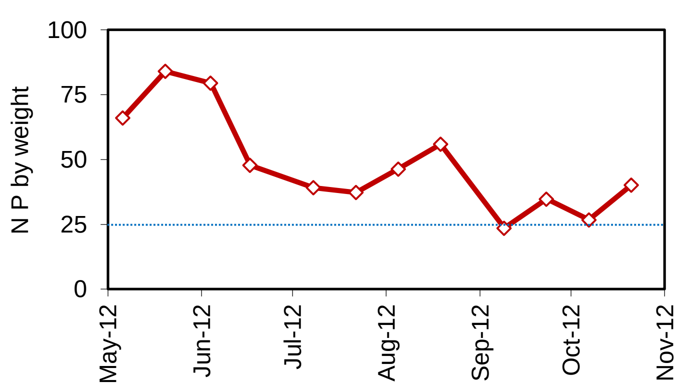

Figure 5. 2012 Pipe Lake N:P ratio. Values below the blue line indicate a potential nutrient advantage for cyanobacteria.

The chlorophyll-*a* level dropped in early May, and remained low through the season with the exception of one higher value in July (Figure 6). Concentrations climbed slightly in late September through October with fall turnover. Pheophytin, which is a degradation product of chlorophyll, stayed below the minimum detection level until the last sampling date, when it rose slightly. This suggests that overall phytoplankton concentrations remained low in Pipe Lake throughout the summer and climbed only slightly in fall with turnover, consistent with phosphorus limitation. This is very similar to what was observed in Lake Lucerne over the season, making it more likely that the chlorophyll peak in July reflected a true increase in phytoplankton.

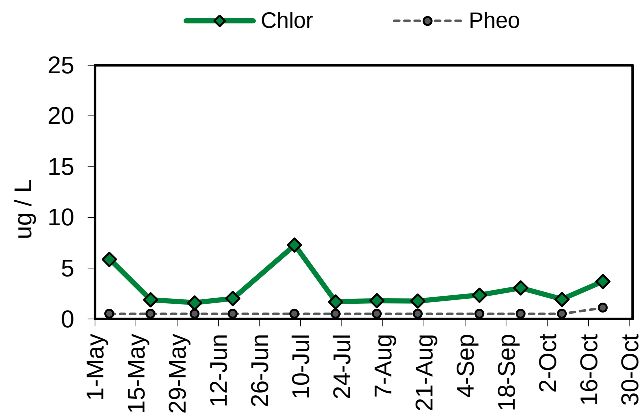

Figure 6. WY 2012 Pipe Lake Chlorophyll-*a* and Pheophytin concentrations

Water column profiles

Profile water temperatures collected in May indicated stratification was present, but the temperatures recorded in August were anomalous, suggesting a thermometer malfunction or misreading, as all other indicators indicated a thermocline was still present (Table 1). In addition there is no history of water mixing during summer in Pipe Lake, which is quite deep relative to its surface area.

The May profile did not show increased total phosphorus, orthophosphate (OPO4), or ammonia (NH3) in the bottom water, but all had risen considerably by August. This indicates that low oxygen conditions were established in the bottom water of Pipe Lake by late summer, resulting in some phosphorus release from the sediments that contributed to internal loading. Chlorophyll-*a* data indicated that shallow water algae were approximately equivalent in May and August, with more present in the middle depth than at the surface on both occasions.

Table 1. 2012 Pipe Lake profile sample results. Secchi and Depth in meters. Temperature in degrees Celsius. Chlorophyll and Pheophytin in ug/L. Nitrogen, phosphorus, and alkalinity in mg /L. UV254 in absorption units. Sample values below minimum detection level (MDL) are marked in bold, red with the MDL value.

Lake name	Date	Secchi	Depth	DegC	Chlor-a	Pheo	Total N	NH3	Total P	OPO4	UV254	Total Alk
Pipe	5/20/12	4.0	1	18.0	1.90	**0.5**	0.496	0.006	0.0059	**0.002**	0.0809	29.7
Pipe			10	7.0	4.47	**0.5**	0.722		0.0119			
Pipe			19	5.0			0.691	0.013	0.0146	0.0032		
Pipe	8/19/12	5.1	1	23.0	1.77	**0.5**	0.302	0.018	0.0054	**0.002**	0.053	32.8
Pipe			10	22.0	7.62	**0.5**	0.584		0.0093			
Pipe			19	21.0			0.768	0.506	0.0772	0.031		

Alkalinity, also known as acid neutralizing capacity or buffering capacity, was relatively low and essentially equivalent to adjoining Lake Lucerne, making the lake somewhat sensitive to pH changes. Water color measurements (UV254) also were very low, contributing to water clarity and indicating that dissolved organic carbon was not an important component in the lake water.

TSI Ratings (Pipe Lake)

A common method of tracking water quality trends in lakes is by calculating the "trophic state index" (TSI), developed by Robert Carlson in 1977. TSI indicators predict the biological productivity of the lake based on water clarity (Secchi) and concentrations of TP and chlorophyll *a* (see discussion in the overview).

The 2012 TSI indicators for chlorophyll *a* and Secchi were very close to each other in the lower range of mesotrophy. The TSI –TP indicator was in the lower oligotrophic range (Figure 7). Pipe Lake has been solidly in the range for oligotrophy for some time, and it appears to have been essentially stable since 2003.

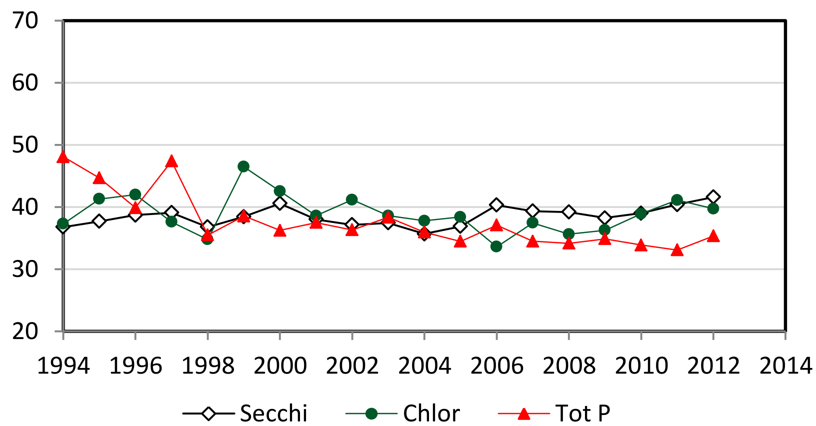

Figure 7. Pipe Lake Trophic State Indicators over time

A trend line run through the TSI-TP indicator values since 1998 shows a decreasing trend over time (Figure 8). An R2 value of 0.456 indicates that 46% of the variability over time can be explained by the trend. This is similar to the decreasing trend observed in Lake Lucerne, suggesting that stormwater controls connected to residential development in the area have been successful to-date in preventing an increase in nutrient delivery to these two lakes.

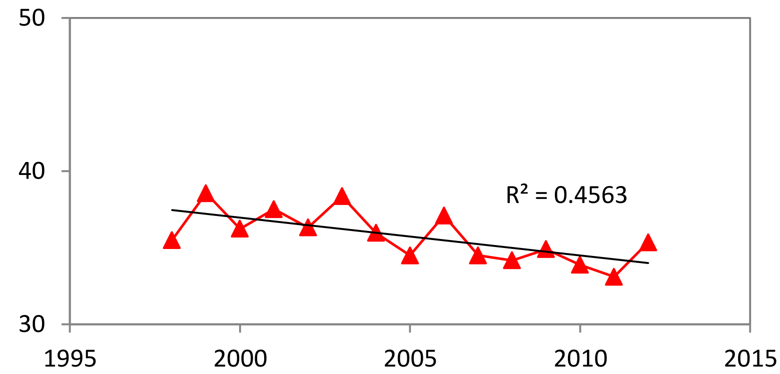

Figure 8. Pipe Lake TSI-TP trend since 1998.

Conclusions and Recommendations

Based on monitoring data, water quality in Pipe Lake appears to have been stable over the last decade or longer, although the values were more variable in the earlier years of the monitoring. High N:P ratios indicate conditions in the lake are not generally favorable for nuisance bluegreen algae blooms. However, the 2012 data show N:P ratios becoming smaller in the fall, which might encourage cyanobacteria towards the end of the recreational season.

With the sunset of the hydrilla eradication project, the city and the residents around the lake should be vigilant in looking for invasive aquatic plants, such as Eurasian watermilfoil and Hydrilla, as the aquatic vegetation returns to the lake.

Lake Wilderness

Volunteer monitoring began at Lake Wilderness in the mid 1970s and has continued through 2012, with few gaps over time. The data indicate this 67-acre lake is moderate in primary productivity (mesotrophic) with generally good water quality.

Of the three lakes in Maple Valley, Wilderness is the only one that has an active “Level I” volunteer, whose monitoring consists of daily precipitation and water level readings, as well as weekly measurements of water temperature and clarity through the entire water year. All 3 lakes have “Level II” volunteers who go out on the lake every two weeks between May and October to take water samples for analysis and measure temperatures and clarity as well.

Lake Wilderness has a public access boat launch and a large city park with a bathing beach, as well as a regional public trail that runs along the east side of the lake. There is a history of Eurasian watermilfoil infestation, with control activities funded and monitored by the community and the city of Maple Valley. Residents have been active stewards of the lake through the years and should continue to watch for new patches of Eurasian milfoil, as well as other noxious weeds that might invade the lake, such as Brazilian elodea.

Physical Parameters

Excellent records of precipitation and water level were kept over the year (Figure 1). The lake level, which generally follows the regional pattern of winter high - summer low stands, increased in the winter and then began to decrease in early spring. While there was some decrease in the lake level through the summer, the lake level remained fairly steady throughout the year, unlike some years in the past when large swings in lake level have been observed. There was a difference of 42 cm between the highest and lowest daily stands during the year, distinctly less than the difference recorded for many previous years.

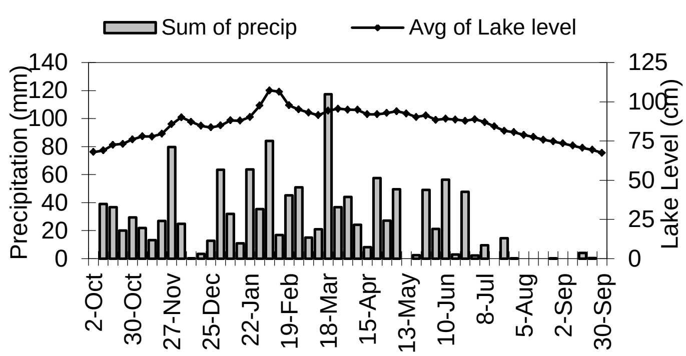

Figure 1. WY 2012 Lake Wilderness weekly water level and precipitation

Secchi transparency ranged from 3.0 to 8.0 m through the year (Figure 2). The summer average of 5.0 m placed it among the clearest of the small lakes monitored in 2012. However, water clarity fluctuated periodically throughout the season. The shallower

Secchi readings in the summer appear to be occurring at about the same time as the higher chlorophyll levels found in the lake during water quality monitoring. There could be something similar occurring in the winter during those times when the Secchi readings were lower as well, although Secchi depth can also be influenced by sediment entering the lake in stormwater or mixed up from bottom sediments during high wind events.

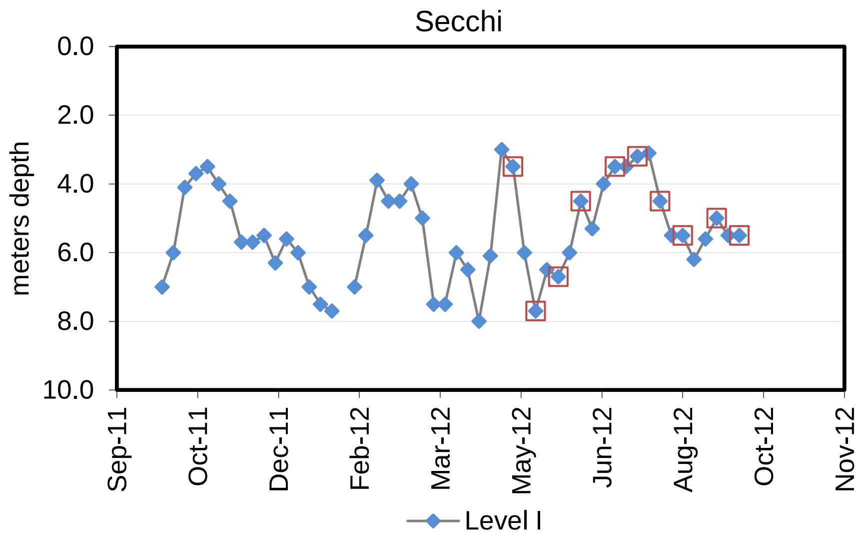

Figure 2. WY 2012 Lake Wilderness Secchi

Annual water temperatures ranged from 3.5 to 24.0 degrees Celsius (Figure 3), with a summer average of 19.7 degrees Celsius, placing Lake Wilderness among the warmer of the 12 lakes monitored during the summer in 2012.

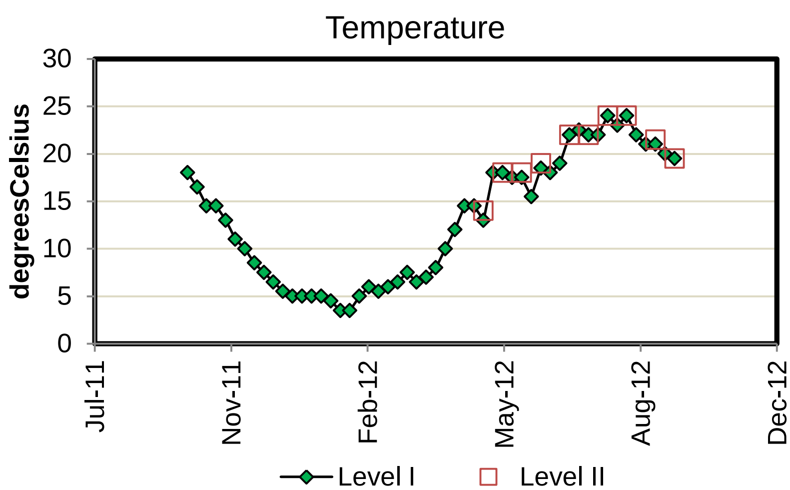

Figure 3. WY 2012 Lake Wilderness Temperature

Mean summer water temperatures over the years that Lake Wilderness has been monitored have varied between years (Figure 4), but to-date show no statistically strong trend toward change through time. A trend line run through the data is flat with a very low correlation coefficient, suggesting general stability through the years monitored rather than a directional change through time.

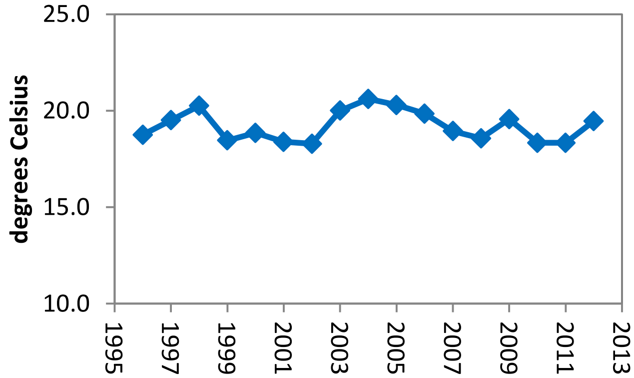

Figure 4. Mean May – October 1m water temperatures for Lake Wilderness

Nutrients and Chlorophyll (Lake Wilderness)

Phosphorus and nitrogen are naturally occurring elements necessary in small amounts for both plants and animals. However, many actions associated with residential development can increase concentrations of these nutrients beyond natural levels. In lakes of the Puget Sound lowlands, phosphorus is often the nutrient in least supply, meaning that biological productivity is often limited by the amount of available phosphorus. Increases in phosphorus concentrations can lead to more frequent and dense algae blooms – a nuisance to residents and lake users, and a potential safety threat if blooms become dominated by species that can produce toxins. Samples collected by volunteers are analyzed for total phosphorus (TP) and total nitrogen (TN) concentrations at one meter depth.

Total nitrogen started high and decreased from May through August, after which it remained fairly steady until rising slowly in October (Figure 5). **Total phosphorus** remained low through September and then increased slowly until October when it made a big increase on the last sample date. Note that nitrogen scale is 10x higher than for phosphorus.

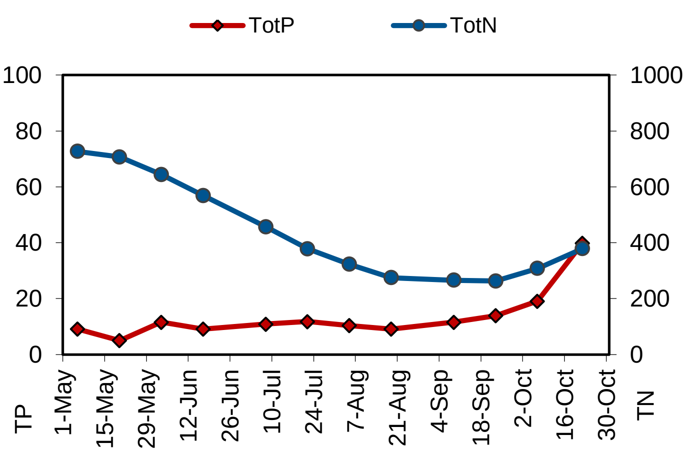

Figure 5. 2012 Lake Wilderness Total Phosphorus and Total Nitrogen in ug/L.

The ratio of nitrogen (N) to phosphorus (P) can be used to determine if nutrient conditions are favorable for the growth of cyanobacteria that can impact beneficial uses of the lake. When N:P ratios are near 25 or below, cyanobacteria may have a competitive advantage in the algal community due to their ability to take nitrogen from the air.

The N:P ratio ranged from 9.5 to 141.0, averaging 45 over the whole season (Figure 6), but the steady decrease from a high in late May to values below 25 in September show that nutrient conditions became hospitable for cyanobacteria in the fall, similar to previous years. However, in 2012 nuisance bluegreen conditions did not develop to the same extent as they have in recent years.

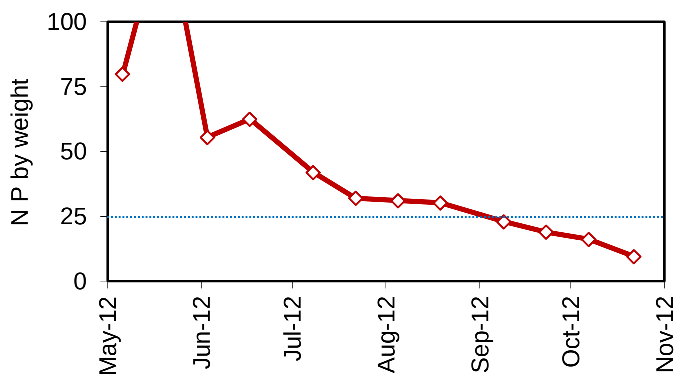

Figure 6. 2012 Lake Wilderness N:P ratio. Values below the blue line indicate a potential nutrient advantage for cyanobacteria.

Chlorophyll *a* started at a higher value, declined until it reached another peak in mid-summer and then remained low until it began to climb steadily from mid-September through the end of the sampling period in October (Figure 7). Pheophytin, which is a degraded chlorophyll molecule, stayed at very low levels, generally below the minimum detection level until autumn when it rose slightly.

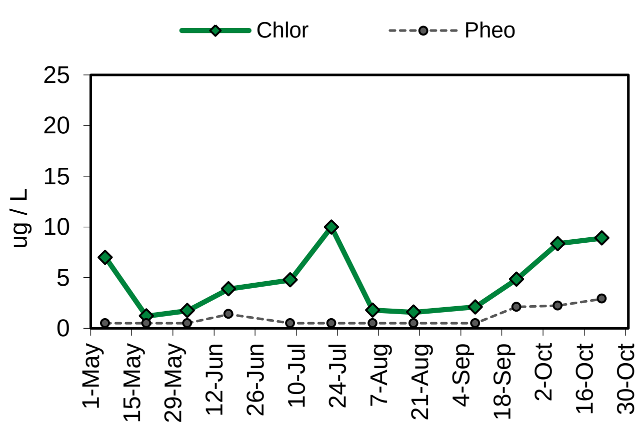

Figure 7. WY 2011 Lake Wilderness Chlorophyll *a* and Pheophytin concentrations

Cyanobacteria toxins

Because of Lake Wilderness has a history of occasionally producing nuisance bluegreen (cyanobacteria) blooms that have produced toxins, routine sampling at the beach for bluegreen species abundance and toxicity between June and October was carried out as part of a regional study that was continued through 2012. Four algal toxins are measured: microcystin, anatoxin-a, saxitoxin and cylindrospermopsin.

In addition, testing for toxicity was carried out in response to a request from the city for information prior to the annual festivities planned on the lake for Opening Day of the fishing season. Only one potential nuisance scum accumulation was reported in 2012, and upon investigation it was determined not to be cyanobacteria.

No samples tested for toxins in 2012 produced values above the minimum detection limit.

Water column profiles

Profile temperature data indicate that thermal stratification was present early in the season and persisted through the summer, though there was a small temperature increase in the deep water by the end of August.

In the May profile event, phosphorus and ammonia were slightly higher in the deep water sample, which suggests that low oxygen conditions may have started to contribute to nutrient recycling from the sediment. However, the high total phosphorus and nitrogen values in the deep water in August were not accompanied by a high orthophosphate value, suggesting there may have been some sediment mixed into the water sample from that date that was contributing to the high TN and TP. While chlorophyll-*a* was fairly evenly distributed through the water column in May, it was very high in the deeper water in August, accompanied by a significant amount of pheophytin (degraded chlorophyll). This also supports the notion that benthic material was included in the deep water sample.

Table 1. 2012 Lake Wilderness profile sample results. Secchi and Depth in meters. Temperature in degrees Celsius. Chlorophyll and Pheophytin in ug/L. Nitrogen, phosphorus, and alkalinity in mg /L. UV254 in absorption units. Sample values below minimum detection level (MDL) are marked in bold, red with the MDL value.

Lake name	Date	Secchi	Depth	DegC	Chlor-a	Pheo	Total N	NH3	Total P	OPO4	UV254	Total Alk
Wilderness	5/20/12	7.7	1	18.0	1.20	**0.5**	0.707	0.027	0.005	**0.002**	0.0322	43.6
Wilderness			4	15.0	1.45	**0.5**	0.833		0.0112			
Wilderness			8	10.5	1.36	**0.5**	0.533	0.078	0.0179	0.004		
Wilderness	8/19/12	5.5	1	24.0	1.59	**0.5**	0.275	**0.005**	0.0091	**0.002**	0.012	46.7
Wilderness			4	23.5	1.71	**0.5**	0.292		0.0117			
Wilderness			8	13.0	28.2	15.4	1.020	**0.005**	0.1300	0.0038		

Alkalinity, also known as acid neutralizing capacity, was higher than in nearby Pipe and Lucerne Lakes, suggesting that water coming into the lake in the Wilderness basin contains more dissolved salts that contribute to buffering capacity. Water color (UV254) was lower than Pipe and Lucerne, contributing to the exceptional water clarity and indicating that dissolved organic carbon from the surrounding watershed was not abundant in the lake water. Wilderness had the lowest UV254 measurements of all the lakes monitored in 2012.

TSI Ratings (Lake Wilderness)

In 2012, the averages for both TSI-Secchi and TSI-TP were together near the threshold between oligotrophy and mesotrophy, but the TSI for chlorophyll was in the mid mesotrophic range (Figure 8). The consistent disparity between the TSI-Secchi and the other two indicators over the years 1998 – 2004 has become less clear since then, with the relationships between all three indicators varying from year to year.

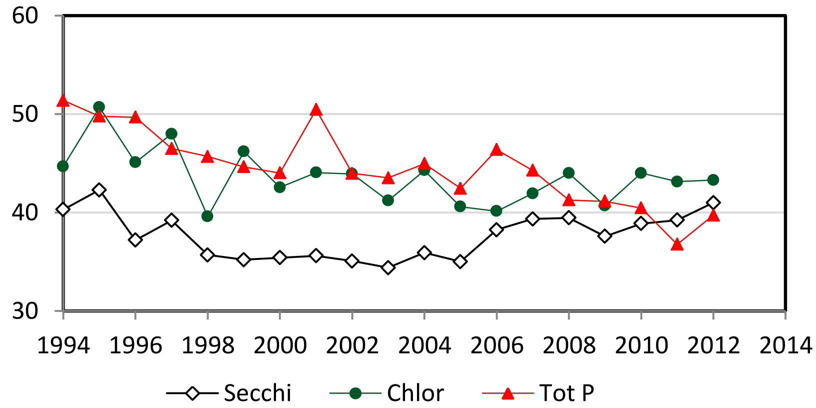

Figure 8. Lake Wilderness Trophic State Indicators over time

There appears to be an overall downward trend in the phosphorus TSI (towards less phosphorus), while there is an accompanying upward trend in the TSI Secchi (towards less clarity). The correlation coefficient of regression lines fit through the values (Figure 9) indicate that the phosphorus trend line is a moderately good fit ($r^2 = 0.544$), which means that about 54% of the variation is explained by a downward trend line. For the Secchi indicator values, 71% of the variability can be explained by an increasing trend over time. Interestingly, the trend for TSI for chlorophyll is totally flat through this same period, and combining the 3 indicators essentially cancels out the two significant trends.

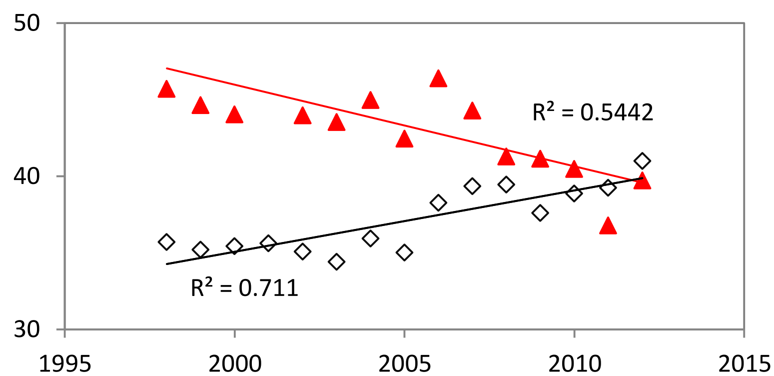

Figure 9. Lake Wilderness trends in TSI phosphorus and Secchi since 1998.

Conclusions and Recommendations

Based on the monitoring data, water quality in Lake Wilderness may be fairly stable over the period measured, but there is a downward trend in phosphorus concentrations and an upward trend in TSI-Secchi transparency. This makes it difficult to project into the future, and continued monitoring is recommended to track where the lake may be heading over time. While N:P ratios are very high in spring, they decrease steadily to low values in the fall that indicate conditions can be favorable for nuisance cyanobacteria. However, no toxic events were detected in 2012.

Close monitoring of algae blooms at the lake, particularly during recreational seasons, should continue to determine how frequently the blooms at the lake produce toxins and how often the concentrations are above the draft state guidelines for recreational activities.